GENERAL PRINCIPLES

MECHANICS

Mechanics is a branch of physical sciences that is concerned with the state of rest or motion of bodies that are subjected to the action of forces. Engineering Mechanics is divided into two major parts, namely *Statics* and *Dynamics*.

1. Statics: is primarily concerned to system of forces applied to body at rest. It includes the following topics: resultant of force system; equilibrium of force system; cables; friction; trusses; frames; centroid; center of gravity; and moment of inertia.

2. Dynamics: is concerned with the accelerated motion of bodies.

Note: We can consider statics as a special case of dynamics, in which the acceleration is zero.

Basic Quantities.

The following four quantities are used throughout mechanics.

1.Length.

is needed to locate the position of a point in space and there by describe the size of a physical system. Once a standard unit of length is defined, one can then quantitatively define distances and geometric properties of a body as multiples of the unit length..

2.Time

is conceived as a succession of events. Although the principles of statics are time independent, this quantity does play an important role in the study of dynamics.

3.Mass

is a property of matter by which we can compare the action of one body with that of another. This property manifests itself as a gravitational attraction between two bodies and provides a quantitative measure of the resistance of matter to a change in velocity.

4.Force.

In general, force is considered as a "push" or "pull" exerted by one body on another. This interaction can occur when there is direct contact between the bodies, such as a person pushing on a wall, or it can occur through a distance when the bodies are physically separated. Examples of the latter type include gravitational, electrical, and magnetic forces. In any case, force is completely by its magnitude, direction and point of application.

5.Particle.

A particle has a mass, but a size that can be neglected. For example, the size of the earth is insignificant compared to the size of its orbit, and therefore the earth can be modeled as a particle when studying its orbital motion. When a body is idealized as a particle, the principles of mechanics reduce to a rather simplified form since the geometry of the body will not be involved in the analysis of the problem.

6.Rigid Body.

A rigid body can be considered as a combination of a large number of particles in which all the particles remain at a fixed distance from one another both before and after applying a load. As a result, the material properties of anybody that is assumed to be rigid will not have to be considered when analyzing the forces acting on the body. In most cases the actual deformations occurring in structures, machines, mechanisms, and the like are relatively small, and the rigid-body assumption is suitable for analysis.

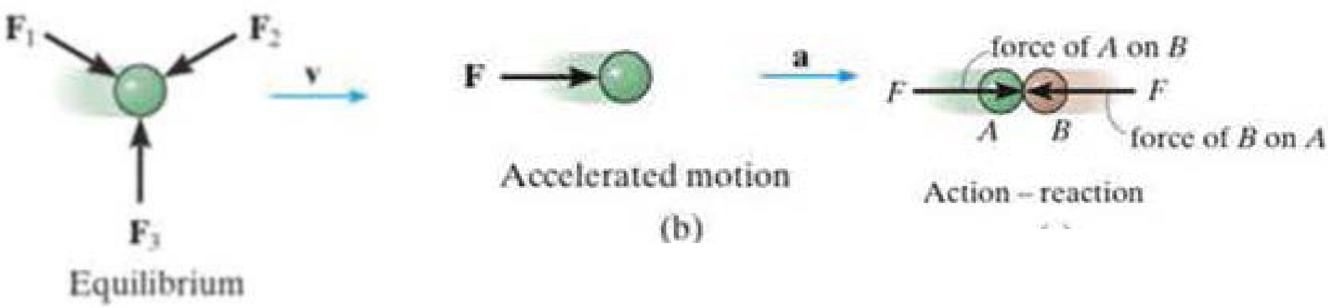
Newton's Three Laws of Motion:

First Law: A particle originally at rest, or moving in a straight line with constant velocity, tends to remain in this state provided the particle is *not* subjected to an unbalanced force.

Second Law: A particle acted upon by an unbalanced force **F** experiences acceleration (***a***) that has the same direction as the force and a magnitude that is directly proportional to the force. If **F** is applied to a particle of mass *m*, this law may be mathematically as

$\mathbf{F} = m\mathbf{a}$

Third Law: The mutual forces of action and reaction between particles are equal (in magnitude), opposite (in direction) and collinear (they lie in the same line of action)



1. Scalar & Vector quantities

<u>A scalar</u> is any positive or negative physical quantity that can be completely specified by its magnitude. Examples of scalar quantities include length, mass, and time.

<u>A vector</u> is any physical quantity that requires both a magnitude and a direction for its complete description. Examples of vectors encountered in statics are force, position, and moment. A vector is shown graphically by an arrow. The length of the arrow represents the magnitude of the vector, and the angle between the vector and a fixed axis defines the direction of its line of action.

2. Units of Measurement

The four basic quantities length, time, mass, and force are measured by two main units, which are the SI Units (The International System of units) and the U.S. Units.

Name	**Length**	**Mass**	**Time**	**Force**
SI Units	Meter (m)	kilogram (kg)	Second (s)	Newton (N)
U.S. Units	Foot (ft)	slug ($\frac{Ib.s^2}{ft}$)	Second (s)	pound (Ib)

2.1. Prefixes

Multiple	**Exponential Form**	**Prefix**	**SI Symbol**
1 000 000 000	10^9	Giga	G
1 000 000	10^6	Mega	M
1 000	10^3	Kilo	k
0.001	10^{-3}	Milli	m
0.000 001	10^{-6}	Micro	µ
0.000 000 001	10^{-9}	Nano	n

2.2. Conversion of Units

1 hr = 60 min = 3600 s

1 m = 100 (or 10^2) cm = 1000 (or 10^3) mm

1 ft = 12 in (inch)

1 in = 25.4 mm >>>> 1ft = 0.3048 m

1 Ib = 4.448 N

1 slug = 14.59 kg

EXAMPLE

Convert 2 km/h to m/s How many ft/s is this?

SOLUTION

Since 1 km = 1000 m and 1 h = 3600 s, the factors of conversion are arranged in the following order, so that a cancellation of the units can be applied:

$$2\ \text{km/h} = \frac{2\ \cancel{\text{km}}}{\cancel{\text{h}}}\left(\frac{1000\ \text{m}}{\cancel{\text{km}}}\right)\left(\frac{1\ \cancel{\text{h}}}{3600\ \text{s}}\right)$$

$$= \frac{2000\ \text{m}}{3600\ \text{s}} = 0.556\ \text{m/s} \qquad \textit{Ans.}$$

From Table 1–2, 1 ft = 0.3048 m. Thus,

$$0.556\ \text{m/s} = \left(\frac{0.556\ \cancel{\text{m}}}{\text{s}}\right)\left(\frac{1\ \text{ft}}{0.3048\ \cancel{\text{m}}}\right)$$

$$= 1.82\ \text{ft/s} \qquad \textit{Ans.}$$

NOTE: Remember to round off the final answer to three significant figures.

EXAMPLE

Convert the quantities 300 lb · s and 52 slug/ft^3 to appropriate SI units.

SOLUTION

Using Table 1–2, 1 lb = 4.448 N.

$$300\ \text{lb}\cdot\text{s} = 300\ \cancel{\text{lb}}\cdot\text{s}\left(\frac{4.448\ \text{N}}{1\ \cancel{\text{lb}}}\right)$$

$$= 1334.5\ \text{N}\cdot\text{s} = 1.33\ \text{kN}\cdot\text{s} \qquad \textit{Ans.}$$

Since 1 slug = 14.59 kg and 1 ft = 0.3048 m, then

$$52\ \text{slug/ft}^3 = \frac{52\ \cancel{\text{slug}}}{\cancel{\text{ft}^3}}\left(\frac{14.59\ \text{kg}}{1\ \cancel{\text{slug}}}\right)\left(\frac{1\ \cancel{\text{ft}}}{0.3048\ \text{m}}\right)^3$$

$$= 26.8(10^3)\ \text{kg/m}^3$$

$$= 26.8\ \text{Mg/m}^3 \qquad \textit{Ans.}$$